The documentation and process conversion measures necessary to comply with this Notice shall be completed by 31 December 1993.

NOTICE OF CHANGE

INCH-POUND

MIL-STD-750C
NOTICE 7
30 June 1993

MILITARY STANDARD

TEST METHODS FOR SEMICONDUCTOR DEVICES

TO ALL HOLDERS OF MIL-STD-750C:

1. THE FOLLOWING PAGES OF MIL-STD-750C HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

METHOD	NEW PAGE	DATE	SUPERSEDED PAGE	DATE
---	7b	30 June 1993	7b	30 April 1992
---	7c	30 April 1992	7c	REPRINTED WITHOUT CHANGE
---	13	30 June 1993	13	30 April 1992
---	14	30 June 1993	14	30 April 1992
---	15	30 June 1993	15	30 April 1992
---	16	30 August 1992	16	REPRINTED WITHOUT CHANGE
---	17/18	30 June 1993	17/18	30 April 1992
1038.2	1	30 April 1992	1	REPRINTED WITHOUT CHANGE
1038.2	2	30 June 1993	2	30 April 1992
1055.1	1	30 June 1993	1	30 April 1992
1055.1	2	30 June 1993	2	30 April 1992
1056.4	1	30 August 1992	1	REPRINTED WITHOUT CHANGE
1056.4	2	30 June 1993	2	30 April 1992
1071.5	3	30 April 1991	3	REPRINTED WITHOUT CHANGE
1071.5	4	30 June 1993	4	30 April 1991
1071.5	11	30 June 1993	11	30 April 1991
1071.5	12	30 April 1991	12	REPRINTED WITHOUT CHANGE
2076.2	5	17 September 1987	5	REPRINTED WITHOUT CHANGE
2076.2	6	30 June 1993	6	23 February 1983
3101.1	5	30 June 1993	5	30 April 1991
3101.1	6	30 April 1991	6	REPRINTED WITHOUT CHANGE

2. THE FOLLOWING TEST METHODS OF MIL-STD-750C HAVE BEEN REVISED AND SUPERSEDE THE TEST METHOD LISTED:

METHOD	DATE	SUPERSEDED METHOD	DATE
1019.4	30 June 1993	1019.3	30 April 1991
1022.5	30 June 1993	1022.4	30 April 1992

3. THE FOLLOWING NEW METHODS HAVE BEEN ADDED:

NEW METHOD	TITLE	DATE
1018	Internal Water-Vapor Content.	
3490	Clamped, Inductive, Switching, Safe, Operating Area for MOS Gated Power Transistors.	
5002	Capacitance-Voltage Measurements to Determine Oxide Quality.	

4. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

5. Holders of MIL-STD-750C will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or canceled.

CONCLUDING MATERIAL

Custodians:
Army - ER
Navy - EC
Air Force - 17
NASA - NA

Review activities:
Army - AR, MI
Navy - SH
Air Force - 19, 85, 99
DLA - ES

User activities:
Navy - AS, CG, MC, OS
Air Force - 13

Preparing activity:
Navy - EC

Agent:
DLA - ES

(Project 5961-1317)

4.5 Requirements for HTRB and burn-in.

a. The temperature of 20°C minimum is the ambient air temperature to which all devices should be exposed during power screening where room ambient is specified.

* b. An increase in effective ambient temperature from cumulative induced power to devices under test shall not result in device junction temperature exceeding maximum ratings.

c. Ambient temperature shall not be measured in the convection current (above) or downstream (Fan Air) of devices under test.

d. Moving air greater than 30 CFM (Natural convection) may be allowed for the purpose of temperature equalization within high device density burn-in racks.

e. High velocity or cooled air shall not be used for the purpose of increasing device ratings.

f. Power up of burn-in racks may occur when ambient is less than specified. When thermal equilibrium has been reached, or 5 hours maximum has occurred, the ambient shall be at the specified value. Time accrued prior to reaching specified ambient shall not be chargeable, to the life test duration.

g. If the ambient at the five hour, or beyond, point is not the specified value a nonconformance shall exist requiring corrective action.

h. Time is not chargeable during the period when specified conditions are not maintained. If device maximum ratings are exceeded and the manufacturer intends to submit the lot affected, the product on test must be evaluated by re-starting the burn-in or HTRB from zero hours at the specified temperature and verifying that the end-point failure rate is typical for this product type from a review of established records.

* i. Chamber temperature for HTRB and burn-in shall be controlled to ±3 percent of the specified value (unless otherwise specified in 4.1.1). This temperature shall be maintained within the chamber. Forced air may be used to equalize temperature within the chamber but shall not be used as a coolant to increase device power capability.

4.6 Bias requirements.

a. Bias errors at the power supply source caused by changing power supply loads during temperature transitions shall not exceed ±5 percent of that specified value.

b. Bias values at the source, during stabilized conditions, shall not exceed ±3 percent of the specified value.

c. Burn-in apparatus shall be arranged so as to result in the approximate average power dissipation for each device whether devices are tested individually or in a group. Bias and burn-in circuitry tolerances should not vary test conditions to individual devices by more than ±5 percent of specified conditions.

d. Normal variation in individual device characteristics need not be compensated for by burn-in circuitry.

e. Burn-in equipment shall be arranged so that the existence of failed or abnormal devices in a group does not negate the effect of the test for other devices in the group. Periodic verification will assure that specified conditions are being maintained. Verification shall be performed, as a minimum, at the starting and end of screening.

f. Lead, stud, or case mounted devices shall be mounted in their normal mounting configuration and the point of mechanical connection shall be maintained at no less than the specified ambient.

Numerical index of test methods

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1015	Steady-state primary photocurrent irradiation procedure (electron beam).
1016	Insulation resistance.
1017.1	Neutron irradiation.
*1019.3	Steady-state total dose irradiation procedure.
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*1022.4	Resistance to solvents.
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METHOD 1018

INTERNAL WATER-VAPOR CONTENT

1. PURPOSE. The purpose of this test is to measure the water-vapor content of the atmosphere inside a metal or ceramic hermetically-sealed device. It can be destructive (procedures 1 and 2) or nondestructive (procedure 3).

2. APPARATUS. The apparatus for the internal water-vapor content test shall be as follows for the chosen procedure:

2.1 Procedure 1. (Procedure 1 measures the water-vapor content of the device atmosphere by mass spectrometry.) The apparatus for procedure 1 shall consist of:

a. A mass spectrometer capable of reproducibly detecting the specified moisture content for a given volume package with a factor of ten sensitivity safety margin (i.e., for a specified limit of 5,000 ppmv, .01 cc, the mass spectrometer shall demonstrate a 500 ppmv or less absolute sensitivity to moisture for a package volume of .01 cc). The smallest volume shall be considered the worst case. The calibration of the mass spectrometer shall be accomplished at the specified moisture limit (±20 percent) using a package simulator which has the capability of generating at least three known volumes of gas ±10 percent on a repetitive basis by means of a continuous sample volume purge of known moisture content ±10 percent. Moisture content shall be established by the standard generation techniques (i.e., 2 pressure, divided flow, or cryogenic method). The absolute moisture shall be measured by an NIST calibrated moisture dew point analyzer at least once every 2 years. The NIST calibrated dew pointer shall be returned to the National Institute of Standards and Technology at least once each year for recalibration. Calibration records shall be kept on a daily basis and made available to DCAS personnel. Gas analysis results obtained by this method shall be considered valid only in the moisture range or limit bracketed by at least two (volume or concentration) calibration points (i.e., 5,000 ppmv between .01 - .1 cc or 1,000 - 5,000 ppmv between .01 - .1 cc). A best fit curve shall be used between volume calibration points. Corrections of sensitivity factors deviating greater than 10 percent from the mean between calibration points shall be required.

b. A vacuum opening chamber which can contain the device and a vacuum transfer passage connecting the device to the mass spectrometer of 2.1a. The transfer passage shall be maintained at 125°C ±5°C. The fixturing in the vacuum opening chamber shall position the specimen as required by the piercing arrangement of 2.1c, and maintain the device at 100°C ±5°C for a minimum of 10 minutes prior to piercing.

c. A piercing arrangement functioning within the opening chamber or transfer passage of 2.1b, which can pierce the specimen housing (without breaking the mass spectrometer chamber vacuum and without disturbing the package sealing medium), thus allowing the specimen's internal gases to escape into the chamber and mass spectrometer.

NOTE: A sharp-pointed piercing tool, actuated from outside the chamber wall via a bellows to permit movement, should be used to pierce both metal and ceramic packages. For ceramic packages, the package lid or cover should be locally thinned by abrasion to facilitate localized piercing.

2.2 Procedure 2. (Procedure 2 measures the water-vapor content of the device atmosphere by integrating moisture picked up by a dry carrier gas at 50°C.) The apparatus for procedure 2 shall consist of:

a. An integrating electronic detector and moisture sensor capable of reproducibly detecting a water-vapor content of 300 ±50 ppmv moisture for the package volume being tested. This shall be determined by dividing the absolute sensitivity in micrograms H_2O by the computed weight of the gas in the device under test, and then correcting to ppmv.

b. A piercing chamber or enclosure, connected to the integrating detector of 2.2a, which will contain the device specimen and maintain its temperature at 100°C ±5°C during measurements. The chamber shall position the specimen as required by the piercing arrangement. The piercing mechanism shall open the package in a manner which will allow the contained gas to be purged out by the carrier gas or removed by evacuation. The sensor and connection to the piercing chamber will be maintained at a temperature of 50°C ±2°C.

2.3 Procedure 3. (Procedure 3 measures the water-vapor content of the device atmosphere by measuring the response of a calibrated moisture sensor or an IC chip which is sealed within the device housing, with its electrical terminals available at the package exterior.) The apparatus for procedure 3 shall consist of one of the following:

a. A moisture sensor element and readout instrument capable of detecting a water-vapor content of 300 ±50 ppmv while sensor is mounted inside a sealed device.

b. Metallization runs on the device being tested isolated by back-biased diodes which when connected as part of a bridge network can detect 2,000 ppmv within the cavity. The chip shall be cooled in a manner such that the chip surface is the coolest surface in the cavity. The device shall be cooled below dew point and then heated to room temperature as one complete test cycle.

NOTE: Suitable types of sensors may include (among others) parallel or interdigitated metal stripes on an oxidized silicon chip, and porous anodized-aluminum structures with gold-surface electrodes.

Surface conductivity sensors may not be used in metal packages without external package wall insulation. When used, the sensor shall be the coolest surface in the cavity. It should be noted that some surface conductivity sensors require a higher ionic content than available in ultraclean CERDIP packages. In any case, correlation with mass spectrometer procedure 1 shall be established by clearly showing that the sensor reading can determine whether the cavity atmosphere has more or less than the specified moisture limit at 100°C.

3. PROCEDURE. The internal water-vapor content test shall be conducted in accordance with the requirement of procedure 1, procedure 2, or procedure 3. Devices containing desiccants or organics shall be prebaked for 12 to 24 hours at 100°C ±5°C prior to hot insertion into apparatus.

3.1 Procedure 1. The device shall be hermetic in accordance with test method 1014, and free from any surface contaminants which may interfere with accurate water-vapor content measurement.

After device insertion, the device and chamber shall be pumped down and baked out at a temperature of 100°C ±5°C until the background pressure level will not prevent achieving the specified measurement accuracy and sensitivity. After pumpdown, the device case or lid shall be punctured and the following properties of the released gases shall be measured, using the mass spectrometer:

a. The increase in chamber pressure as the gases are released by piercing the device package. A pressure rise of less than 50 percent of normal for that package volume and pressurization may indicate that (1) the puncture was not fully accomplished, (2) the device package was not sealed hermetically, or (3) does not contain the normal internal pressure.

b. The water-vapor content of the released gases, as a proportion (by volume) of the total gas content.

c. The proportions (by volume) of the other following gases: N_2, He, Mass 69 (fluorocarbons), O_2, Ar, H_2, CO_2, CH_4, and other solvents, if available, in the order stated. Calculations shall be made and reported on all gases present greater than 1 percent by volume. Data reduction shall be performed in a manner which will preclude the cracking pattern interference from other gas specie in the calculations of moisture content. Data shall be corrected for any system dependent matrix effects such as the presence of hydrogen in the internal ambient.

3.1.1 Failure criteria.

a. A device which has a water-vapor content greater than the specified maximum value shall constitute a failure.

b. A device which exhibits an abnormally low total gas content, as defined in 3.1a, shall constitute a failure, if it is not replaced. Such a device may be replaced by another device from the same population; if the replacement device exhibits normal total gas content for its type, neither it nor the original device shall constitute a failure for this cause.

c. Data analysis on devices containing desiccants or organics shall be terminated after 95 percent of the gas has been analyzed in a dynamic measurement system or data shall be taken after pressure has stabilized for a period of 2 minutes in a static system or in any manner which approaches the true measurement of ambient moisture in equilibrium at 100°C within the cavity.

3.2 Procedure 2. The device shall be hermetic in accordance with test method 1014, and free from any surface contaminants which may interfere with accurate water-vapor content measurement.

After device insertion into the piercing chamber, gas shall be flowed through the system until a stable base-line value of the detector output is attained. With the gas flow continuing, the device package shall then be pierced so that a portion of the purge gas flows through the package under test and the evolved moisture integrated until the base-line detector reading is again reached. An alternative allows the package gas to be transferred to a holding chamber which contains a moisture sensor and a pressure indicator. System is calibrated by injecting a known quantity of moisture or opening a package of known moisture content.

3.2.1 Failure criteria.

a. A device which has a water-vapor content (by volume) greater than the specified maximum value shall constitute a failure.

b. After removal from the piercing chamber, the device shall be inspected to ascertain that the package has been fully opened. A device package which was not pierced shall constitute a failure, if the test is not performed on another device from the same population; if this retest sample or replacement is demonstrated to be pierced and meets the specified water-vapor content criteria, the specimen shall be considered to have passed the test.

c. A package which is a leaker in the purge case will be wet and counted as a failure. In the case of evacuation, a normal pressure rise shall be measured as in 3.1a.

3.3 Procedure 3. The moisture sensor shall be calibrated in an atmosphere of known water-vapor content, such as that established by a saturated solution of an appropriate salt or dilution flow stream. It shall be demonstrated that the sensor calibration can be verified after package seal or that post seal calibration of the sensor by lid removal is an acceptable procedure.

The moisture sensor shall be sealed in the device package or, when specified, in a dummy package of the same type. This sealing shall be done under the same processes, with the same die attach materials and in the same facilities during the same time period as the device population being tested.

The water-vapor content measurement shall be made, at 100°C or below, by measuring the moisture sensor response. Correlation with procedure 1 shall be accomplished before suitability of the sensor for procedure 3 is granted. It shall be shown the package ambient and sensor surface are free from any contaminating materials such as organic solvents which might result in a lower than usual moisture reading.

3.3.1 Failure criteria. A specimen which has a water-vapor content greater than the specified maximum value shall constitute a failure.

4. Implementation. Suitability for performing method 1018 analysis is granted by the qualifying activity for specific limits and volumes. Method 1018 calibration procedures and the suitability survey are designed to guarantee ±20 percent lab-to-lab correlation in making a determination whether the sample passes or fails the specified limit. Water vapor contents reported either above or below the (water vapor content - volume) range of suitability are not certified as correlatable values. This out of specification data has meaning only in a relative sense and only when one laboratory's results are being compared. Suitability status has been granted for a specification limit of 5,000 ppmv and package volumes falling between .01 cc and .85 cc. The range of suitability for each laboratory will be extended by the qualifying activity when the analytical laboratories demonstrate an expanded capability. Information on current analytical laboratory suitability status can be obtained by writing DESC/EQT, Dayton, OH 45440.

* 5. SUMMARY. The following details shall be specified in the applicable acquisition document:

a. The procedure (1, 2, or 3) when a specific procedure is to be used (see 3).

* b. The maximum allowable water-vapor content falling within the range of suitability as specified in test method 5005, 5008, or 5010.

METHOD 1019.4

STEADY-STATE TOTAL DOSE IRRADIATION PROCEDURE

* 1. Purpose. This test procedure defines the requirements for testing discrete packaged semiconductor devices for total dose effects by ionizing radiation from a Cobalt-60 (60_{Co}) gamma ray source. This procedure includes only steady-state irradiations, and is not applicable to pulse type irradiations. This test may produce severe degradation of the electrical properties of irradiated devices.

1.1 Definitions. Definitions of terms used in this procedure are given below:

a. In-flux tests: Electrical measurements made on devices during radiation exposure.

b. Not in-flux tests: Electrical measurements made on devices at any time other than during irradiation.

c. Remote tests: Electrical measurements made on devices which are physically removed from the irradiation location for the measurements.

* d. Ionizing radiation effects. The changes in the electrical parameters of a device or integrated circuit results from radiation-induced charge. It is also referred to as total dose effects.

* 2. Apparatus. The apparatus shall consist of the radiation source, electrical test instrumentation, test circuit board(s), cable, interconnect board or switching system, if used, and appropriate dosimetry measurement system, if used. Adequate precautions shall be observed to obtain an electrical measurement system with sufficient insulation, ample shielding, satisfactory grounding, and with suitable low noise from the main power supply.

* 2.1 Radiation source. The radiation source used in the test shall be the uniform field of a Cobalt-60 gamma ray source. Uniformity of the radiation field in the volume where devices are irradiated shall be ±10 percent as measured by the dosimetry system, unless otherwise specified. Changes in geometry from one test to another require remeasurement of the field uniformity.

* 2.1.1 Cobalt-60 source. The gamma ray field of a Cobalt-60 source shall be calibrated at least every three years to an uncertainty of no more than ±5 percent as measured with an appropriate dosimetry system whose calibration is traceable to the National Institute of Standards and Technology (NIST). Corrections for Cobalt-60 source decay shall be made monthly.

* 2.2 Dosimetry system. The gamma ray field of the radiation source shall be characterized by appropriate dosimetry (traceable to NIST) methods prior to irradiation of test devices. The following DoD adopted American Society for Testing and Materials (ASTM) standards or their equivalents shall be used:

ANSI/ASTM E 666-78	Standard Method for Calculation of Absorbed Dose from Gamma or X Radiation.
ANSI/ASTM E 668-78	Standard Practice for the Application of Thermoluminescence-Dosimetry (TLD) Systems for Determining Absorbed Dose in Radiation-Hardness Testing of Electronic Devices.

* ASTM E 1250 - Standard Method for Application of Ionization Chambers to Assess the Low Energy Gamma Component of Cobalt 60 Irradiators Used in Radiation Hardness Testing of Silicon electronic Devices.

* ASTM E 1275 - Standard Practice for Use of a Radiochromic Film Dosimetry System.

* ASTM E 1249 - Minimizing Dosimetry Errors in Radiation Hardness Testing of Silicon Electronic Devices.

* These industry standards address the conversion of absorbed dose from one material to another and the proper use of various dosimetry systems. 1/

* 2.3 Electrical test instruments. All instrumentation used for electrical measurements shall have stability, accuracy, and resolution required for accurate measurement of the electrical parameters. Any instrumentation required to operate in a radiation environment above 10 REM/hour shall be appropriately shielded, or the radiation level must be less than the instrumentation manufacturers recommended maximum.

2.4 Test circuit board(s). Devices to be irradiated shall be mounted on or connected to circuit boards together with any associated circuitry necessary for device biasing during irradiation or for in-site measurements. Unless otherwise specified, all device input terminals and any others which may affect the radiation response shall be electrically connected during irradiation, i.e., not left floating. The geometry and materials of the completed board shall allow uniform irradiation of the devices under test. Good design and construction practices shall be used to prevent oscillations, minimize leakage currents, prevent electrical damage, and obtain accurate measurements. All apparatus used repeatedly in radiation fields shall be checked periodically for physical or electrical degradation. Components which are placed on the test circuit board, other than devices under test, shall be insensitive to the accumulated radiation, or they shall be shielded from the radiation test fixtures, shall be made in such a way that materials will not disturb the uniformity of the radiation field intensity at the device under test.

* 2.5 Interconnect or switching system. This system shall be located external to the radiation environment location, and provides the interface between the test instrumentation and the devices under test. It is part of the entire test system and subject to the limitation specified in 2.4 for leakage between terminals.

* 2.6 Procedure. The test devices shall be irradiated as specified by a test plan. This plan shall specify the device description, radiation conditions, device bias conditions, dosimetry system operating conditions and measurements, and conditions.

* 3.1 Sample selection. Unless otherwise specified, the test samples shall be randomly selected from the parent population and identically packaged. Each part shall be individually identifiable to enable pre- and postirradaition comparison. For device types which are ESD-sensitive, proper handling techniques shall be used to prevent damage to the devices. Only devices which have passed the electrical specification as defined in the test plan shall be submitted to radiation testing.

3.2 Dosimetry measurements. The radiation field intensity at the location of the device under test shall be determined prior to testing by dosimetry or by source decay correction calculations, as appropriate, to assure conformance to test level and uniformity requirements. The dose to the device under test shall be determined one of two ways: (1) by measurement during the irradiation with an appropriate dosimeter, or (2) by correcting a previous dosimetry value for the decay of the 60 to Co source intensity in the intervening time. Appropriate correction shall be made to convert the measured or calculated dose in the dosimeter material to the dose in the device under test.

1/ Copies may be obtained from ASTM, 1916 Race Street, Philadelphia, PA 19103.

3.3 Lead/aluminum (Pb/A1) container. Test specimens shall be enclosed in a Pb/A1 container to minimize dose enhancement effects caused by low-energy, scattered radiation. a minimum of 1.5 mm Pb, surrounding an inner shield of at least 0.7 mm A1, is required. This Pb/A1 container produces an approximate charged particle equilibrium for S1 and for TLD;s such as CaF_2. The radiation field intensity shall be measured inside the Pb/A1 container (1) initially, (2) when the source is changed, or (3) when the orientation of configuration of the source, container, or test-fixture is changed. This measurement shall be performed by placing a dosimeter (e.g., a TLD) in the device-irradiation container at the approximate test-device position. If it can be demonstrated that low-energy scattered radiation is small enough that it will not cause dosimetry errors due to dose enhancement, the Pb/A1 container may be omitted.

3.4 Radiation level(s). The test devices shall be irradiated to the dose level(s) specified in the test plan within ±10%. If multiple irradiations are required for a set of test devices, then the postirradiation electrical parameter measurements shall be performed after each irradiation.

3.5 Radiation dose rate.

3.5.1 Condition A. The dose-rate range shall be between 50 and 2000 rads (Si)/s (0.5 and 20 Gy(Si)/s) for 60 Co. 2/ The dose rates may be different for each radiation dose level in a series; however, the dose rate shall not vary by more than ±10 percent during each irradiation.

3.5.2 Condition B. An alternative, the test may be performed at the dose rate of the intended application, if this is agreed to by the acquisition activity.

3.6 Temperature requirements. Since radiation effects are temperature dependent, devices under test shall be irradiated in an ambient temperature of 24°C ±6°C as measured at a point in the test chamber in close proximity to the test fixture. The electrical measurements shall be performed in an ambient temperature of 25°C ±5°C. If devices are transported to and from a remote electrical measurement site, the temperature of the test devices shall not be allowed to increase by more than 10°C from the irradiation environment. If any other temperature range is required, it shall be specified.

3.7 Electrical performance measurements. The electrical parameters to be measured and functional tests to be performed shall be specified in the test plan. As a check on the validity of the measurement system and pre- and postirradiation data, at least one control sample shall be measured using the operating conditions provided in the governing device specifications. For automatic test equipment, there is no restriction on the test sequence provided that the rise in the device junction temperature is minimized. For manual measurements, the sequence of parameter measurements shall be chosen to allow the shortest possible measurement period. When a series of measurements is made, the tests shall be arranged so that the lowest power dissipation in the device occurs in the earliest measurements and the power dissipation increases with subsequent measurements in the sequence. The pre- and postirradiation electrical measurements shall be done on the same measurement system and the same sequence of measurements shall be maintained for each series of electrical measurements of devices in a test sample. Pulse-type measurements of electrical parameter should be used as appropriate to minimize heating and subsequent annealing effects.

3.8 Test conditions The use of in-flux or not in-flux shall be specified in the test plan. (This may depend on the intended application for which the data is being obtained.) The use of in-flux testing may help to avoid variations introduced by postirradiation time dependent effects. However, errors may be incurred for the situation where a device is irradiated in-flux with static bias, but where the electrical testing conditions require the use of dynamic bias for fraction of the total irradiation period. Not-in-flux testing generally allows for more comprehensive electrical testing, but can be misleading if significant postirradiation time dependent effects occur.

2/ The SI unit for the quantity absorbed dose is the gray, symbol Gy. 100 rad = 1 Gy.

3.8.1 In-flux testing. Each test device shall be checked for operation within specifications prior to being irradiated. After the entire system is in place for the in-flux radiation test, it shall be checked for proper interconnections, leakage (see 2.4), and noise level. To assure the proper operation and stability of the test setup, a control device with known parameter values shall be measured at all operational conditions called for in the test plan. This measurement shall be done either before the insertion of test devices or upon completion of the irradiation after removal of the test devices or both.

3.8.2 Remote testing. Unless otherwise specified, the bias shall be removed and the device leads placed in conductive foam (or similarly shorted) during transfer from the irradiation source to a remote tester and back again for further irradiation. This minimizes postirradiation time dependent effects.

3.8.3 Bias and loading conditions. Bias conditions for test devices during irradiation shall be within ±5 percent of those specified by the test plan. (The bias applied to the test devices shall be selected to produce the greatest radiation induced damage or the worst-case damage for the intended application, if known.) The specified bias shall be maintained on each device in accordance with the test plan. Bias shall be checked immediately before and after irradiation. Care shall be taken in selecting the loading such that the rise in the junction temperature is minimized.

3.9 Postirradiation procedure. Unless otherwise specified, the following time intervals shall be observed:

a. The time from the end of an irradiation to the start of electrical measurements shall be a maximum of one hour.

b. The time to perform the electrical measurements and to return the devices for a subsequent irradiation, if any, shall be within two hours of the end of the prior irradiation.

To minimize time dependent effects, these intervals shall be as short as possible. The sequence of parameter measurements shall be maintained constant through the test series.

3.10 Test report. As a minimum, the report shall include the device type number, CAGE code of the manufacturer, package type, controlling specification, date code, and any other identifying numbers given by the manufacturers, the bias conditions during radiation, the radiation level, time, temperature, and the pre- and pos-radiation recorded readings. The following information is available on request only and is not a requirement for the report:

a. Each data work sheet shall include the test date, the radiation source used, the bias conditions during irradiation, the ambient temperature around the devices during irradiation and electrical testing, the duration of each irradiation, the time between irradiation and the start of the electrical measurements, the duration of the electrical measurements, and the time to the next irradiation when step irradiations are used, the irradiation dose rate, electrical test conditions, dosimetry system and procedures, and the radiation test levels. The pre- and postirradiation data shall be recorded for each part and retained with the parent population data in accordance with the requirements of MIL-S-19500. Any anomalous incidents during the test shall be fully documented and reported.

b. The bias circuit, parameter measurements circuits, the layout of the test apparatus with details of distances and materials used, and electrical noise and current leakage of the electrical measurement system for in-flux testing, shall be reported using drawings or diagrams as appropriate.

4.0 Summary. The following details shall be specified in the applicable acquisition document as required.

a. Device-type number(s), quantity, and governing specification (see 3.1).

b. Radiation dosimetry requirements (see 3.2).

c. Radiation test levels including dose and dose rate (see 3.4 and 3.5).

d. Irradiation, electrical test and transport temperature, if other than as specified in 3.6.

e. Electrical parameters to be measured and device operating conditions during measurement (see 3.7).

f. Test conditions, i.e., in-flux or not-in-flux type tests (see 3.8).

g. Bias conditions for devices during irradiation (see 3.8.3).

h. Time intervals of the postirradiation measurements (see 3.9).

i. Documentation required to be delivered with devices (see 3.10).

METHOD 1022.5

RESISTANCE TO SOLVENTS

1. PURPOSE. The purpose of this test is to verify that the markings will not become illegible on the component parts when subjected to solvents. The solvents will not cause deleterious, mechanical or electrical damage, or deterioration of the materials or finishes.

1.1 Formulation of solvents. The formulation of solvents herein is considered typical and representative of the desired stringency as far as the usual coatings and markings are concerned. Many available solvents which could be used are either not sufficiently active, too stringent, or even dangerous to humans when in direct contact or when the fumes are inhaled.

1.2 Check for conflicts. When this test is referenced, care should be exercised to assure that conflicting requirements, as far as the properties of the specified finishes and markings are concerned, are not invoked.

2. MATERIALS

2.1 Solvent solutions. The solvent solutions used in this test shall consist of the following:

a. A mixture consisting of the following:

(1) One part by volume of isopropyl alcohol, A.C.S. (American Chemical Society) Reagent Grade, or isopropyl alcohol in accordance with TT-I-735, grade A or B, and

(2) Three parts by volume of mineral spirits in accordance with TT-T-291, type II, grade A, or three parts by volume of a mixture of 80 percent by volume of kerosene and 20 percent by volume ethylbenzene.

b. A semiaqueous based solvent (defluxer (e.g., a turpene) consisting of a minimum of 60 percent Limonene and a surfactant heated to 32°C ±5°C. 1/

c. At 63°C to 70°C, a mixture consisting of the following: 2/

(1) 42 parts by volume of deionized water.

(2) 1 part by volume of propylene glycol monomethyl ether.

(3) 1 part by volume of monoethanolamine.

2.1.1 Solvent solutions, safety aspects. Solvent solutions listed in a through d above exhibit some potential for health and safety hazards. The following safety precautions should be observed:

a. Avoid contact with eyes.

b. Avoid prolonged contact with skin.

c. Provide adequate ventilation.

d. Avoid open flame.

e. Avoid contact with very hot surfaces.

1/ Or any equivalent EPA approved HCFC or terpene solvent or demonstrated equivalent.
2/ Normal safety precaution for handling this solution (e.g., same as those for diluted ammonium hydroxide) based on O.S.H.A. rules for monoethanolamine.

2.2 Vessel. The vessel shall be a container made of inert material, and of sufficient size to permit complete immersion of the specimens in the solvent solutions specified in 2.1.

2.3 Brush. The brush shall be a toothbrush with a handle made of a nonreactive material. The brush shall have three long rows of hard bristles, the free ends of which shall lie substantially in the same plane. The toothbrush shall be used exclusively with a single solvent and when there is any evidence of softening, bending, wear, or loss of bristles, it shall be discarded.

3. Procedure. The specimens subjected to this test shall be divided into three groups. Metal lidded leadless chip carrier (LCC) packages shall be preconditioned by immersing the specimens in room temperature RMA flux (in accordance with MIL-F-14256, flux, soldering, liquid, rosin base) for 5 to 10 seconds. The specimens shall then be subjected to an ambient temperature of 215°C ±5°C for 60 seconds +5, -0 seconds. After the preconditioning, each device lid shall be cleaned with isopropyl alcohol. Each group shall be individually subjected to one of the following procedures:

a. The first group shall be subjected to the solvent solution as specified in 2.1a maintained at a temperature of 25°C ±5°C.

b. The second group shall be subjected to the solvent solution as specified in 2.1b maintained at a temperature of 32°C ±5°C.

c. The third group shall be subjected to the solvent solution as specified in 2.1c maintained at a temperature of 63°C to 70°C.

The specimens and the bristle portion of the brush shall be completely immersed for 1 minute minimum in the specified solution contained in the vessel specified in 2.2. Immediately following immersion, the specimen shall be brushed with normal hand pressure (approximately 2 to 3 ounces) for 10 strokes on the portion of the specimen where marking has been applied, with the brush specified in 2.3. Immediately after brushing, the above procedure shall be repeated two additional times, for a total of three immersions followed by brushings. The brush stroke shall be directed in a forward direction, across the surface of the specimen being tested. After completion of the third immersion and brushing, devices shall be rinsed and all surfaces air blown dry. After 5 minutes, the specimens shall be examined to determine the extent, if any, of deterioration that was incurred.

3.1 Optional procedure for the third group. The test specimens shall be located on a test surface of known area which is located 15 ±2.5 centimeters (6 ±1 inches) below a spray nozzle(s) which discharges 0.6 ±.0.02 liters/minute (0.139 gpm) of solution (2.1d) 6.5 square centimeters (1 in^2) of surface area at a pressure of 140 ±30 kilopascal (20 ±5 psi). The specimens shall be subjected to this spray for a period of 10 minutes minimum. After removal and within 5 minutes the specimens shall be examined in accordance with 3.1.1. The specimens may be rinsed with clear water and air blown dried prior to examination.

3.1.1 Failure criteria. After subject to the test, evidence of damage to the device and any specified markings which are missing in whole or in part, faded, smeared, blurred, or shifted (dislodged) to the extent that they cannot be readily identified from a distance of at least 15.0 cm (6 inches) with normal room lighting and without the aid of magnification or with a viewer having a magnification no greater than 3X shall constitute a failure.

4. Summary. The following detail shall be specified in the individual specification: The number of specimens to be tested (see 3).

METHOD 1038.2

BURN-IN (FOR DIODES, RECTIFIERS, AND ZENERS)

1. Purpose. This test is performed to eliminate marginal devices or those with defects resulting from manufacturing aberrations that are evidenced as time and stress dependent failures. Without the burn-in, these defective devices would be expected to result in early lifetime failures under normal use conditions. It is the intent of this test to operate the semiconductor device at specified conditions to reveal electrical failure modes that are time and stress dependent.

a. High temperature reverse bias (HTRB) screens for mobile or temperature activated impurities within (and without) the device's passivation layers. It is equally effective on most device types including diodes, rectifiers, zeners, and transient voltage suppressors.

b. Steady-state operating power (SSOP) when properly specified, simulates actual device operation but with accelerated conditions. Some of the elements of HTRB are combined with screening for die bond integrity. It is effective on some device types including diodes, rectifiers, and zeners. The conditions used for zeners provide the desired HTRB screen concurrently with the SSOP screen.

2. Mounting. Mounting shall be in accordance with the following, unless otherwise specified in the detail specification.

2.1 Test condition A, high temperature reverse bias (HTRB). The method of mounting is usually optional for high temperature bias since little power is dissipated in the device. (Devices with normally high reverse leakage current may be mounted to heat sinks to prevent thermal run-away conditions.)

2.2 Test condition B, steady-state operating power.

a. Devices with leads projecting from the body (axial, etc.) shall be mounted by their leads at least 9.5 mm (3/8-inch) from the body or lead tabulation.

b. Devices designed for case mounting (stud, flange, and disc) shall be mounted by the stud or case according to the design specifications for the package (unless otherwise specified). Care must be exercised to avoid stressing or warping of the package. Thermally conductive compounds may optionally be used provided that they are removed afterwards and do not leave a residue on the package.

c. Surface mount types shall be held by their electrical terminations.

3. Procedure. The semiconductor device shall be subjected to the burn-in at the temperature and for the time specified herein or on the detail specification. Pre-burn-in measurements shall be made as specified. The failure criteria shall be as specified in the appropriate detail specification. If measurements cannot be performed within the specified time, the devices shall be subjected to the same test conditions for a minimum of 24 additional hours before test measurements are performed.

3.1 Test condition A, high temperature reverse bias (HTRB). HTRB is performed with the cathode positively biased at an artificially elevated temperature for 48 hours minimum, unless otherwise specified. These conditions apply to both rectifiers and to avalanche and zener voltage regulators.

a. The junctions of rectifiers shall be reverse biased at 50 to 85 percent per figure 1038-1 of their rated working peak reverse voltage; avalanche and zener voltage regulators, when specified, shall be reverse biased at 80 percent of their minimum avalanche or zener voltages except when voltage exceeds 2500, see figure 1038-2. The reverse bias shall be a dc bias with less than 20 percent ripple except where rectified (pulsating) dc is permitted. The ambient or case test temperature shall be as specified (normally 150°C for silicon devices) (see figure 1038-2).

b. At the end of the high-temperature test time, as specified, the ambient temperature shall be lowered. The test voltage shall be maintained on the devices until a case temperature of 30 ±5°C is attained. Testing shall be completed within 24 hours after the removal of voltage. After removal of the bias voltage, no other voltage shall be applied to the device before taking the post HTRB reverse current measurement. Post HTRB measurements shall be taken as specified.

Uni-directional transient voltage suppressors shall be treated as avalanche and zener voltage regulators for the purposes of conducting HTRB.

Bi-directional transient voltage suppressors shall be treated as two discrete avalanche or zener voltage regulators (when specified) with each polarity taking turns receiving HTRB and post HTRB testing. Post HTRB testing of one must be completed before reversing the device and commencing HTRB with opposite polarity bias voltage. The second polarity may be achieved either electrically or by mechanically reversing the devices.

* 3.2 Test condition B, steady-state operating power. The devices shall be subjected to the maximum rated test conditions for a minimum of 96 hours, unless otherwise specified. The test temperature shall be as specified. Post burn-in readings shall be taken within 96 hours, unless otherwise specified. If ambient temperature is specified, it shall comply with the general requirements for HTRB or burn-in of this specification (see 4.5). The following indicates the test conditions to be specified for each of the three types of power burn-in tests:

a. Rectifying test. Average rectified current, peak reverse voltage, frequency, and temperature (case, junction, or ambient) as specified in the detail specification, unless otherwise specified.

b. Forward bias test. Forward current and temperature (case or junction) as specified in the detail specification, unless otherwise specified.

c. Voltage regulator (zener) test. Voltage regulator diode current and temperature (case or junction) as specified in the slash drawing, unless otherwise specified. At the end of the test time, the power level shall be reduced to 5 percent of the operating level. If the ambient is artificially elevated, it shall also be reduced to room temperature. The object is to let the devices cool down under bias. When the junction or case temperatures have stabilized to below 50°C, the bias may be removed and the devices tested within 96 hours after removal of reverse bias. No other voltage may be applied to the devices until completion of electrical test.

METHOD 1055.1

MONITORED MISSION TEMPERATURE CYCLE

1. Purpose. This test is to determine the ability of devices to withstand the effect of thermal stress and rapid dimensional change on internal structural elements caused by the application of power in rapidly changing temperature environments as in mission profile system testing.

2. Apparatus. The equipment required shall consist of that listed below and shall have the stated capabilities.

   a. A chamber of sufficient temperature range and change rate capability with cabling exiting through insulated barriers to external bias and monitoring electronics. Cabling for all monitoring equipment shall provide Kelvin connections.

   b. Electronic regulated power supply(s) capable of maintaining the stated bias tolerances.

   c. Electronic voltage monitoring device with capability of indicating an open circuit of 20 microseconds or more in duration.

3. Procedure.

   a. Devices conforming to all electrical and mechanical parameter requirements shall be first subjected to high temperature stabilization bake of MIL-STD-750, method 1032. They shall then be subjected to non-operational thermal shock of MIL-STD-750, method 1051, except that no dwell is required at 25°C. Test condition "C" shall be +175°C, +5°C, -0°C. Temperature shall remain at the stabilized extremes for 10 minutes minimum.

   b. Electrical measurements shall be performed to ensure that proceeding to the monitored thermal cycle portion of this test all devices have remained within specification.

   c. The temperature extremes shall be as stated below (from worse case mission profile requirements of MIL-STD-781, table I), unless otherwise specified.

   d. The temperature and operating profile shall be specified on figure 1055-1. Temperature change rate shall average not less than 5°C per minute, but not greater than 10°C per minute.

   e. The device(s) shall be placed individually or in series connection within the chamber. The device(s) shall be connected to a constant current power supply capable of supplying current to raise the device junction(s) to +125°C minimum, 150°C maximum temperature during the high temperature portion of each cycle.

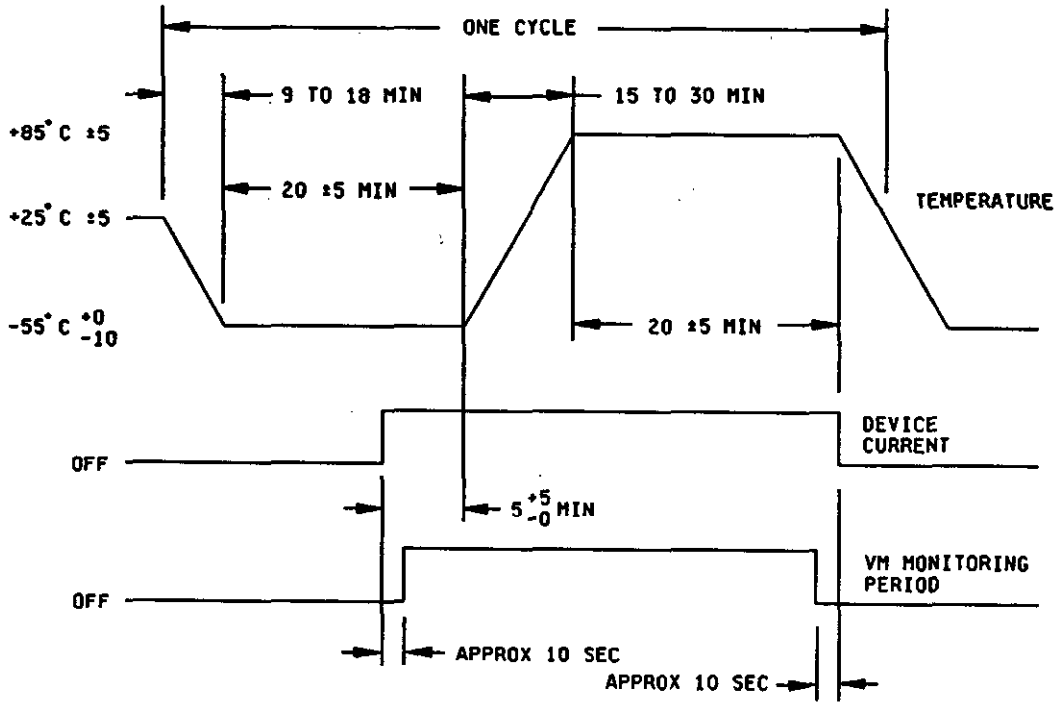


FIGURE 1055-1. Monitored mission cycle.

METHOD 1056.4

THERMAL SHOCK (LIQUID TO LIQUID)

1. Purpose. This test is conducted to determine the resistance of the part to sudden exposure to extreme changes in temperature and to the effect of alternate exposures to these extremes.

1.1 Terms and definitions.

1.1.1 Cycle. A cycle consists of starting at ambient room temperature, proceeding to step 1, then to step 2, or alternately proceeding to step 2, then to step 1, and then back to ambient room temperature without interruption.

1.1.2 Dwell time. The total time the load is immersed in the bath.

1.1.3 Load. The devices under test and the fixtures holding those devices.

1.1.4 Maximum load. The maximum mass of devices and fixtures that can be placed in the bath while maintaining specified temperatures and times.

1.1.5 Specimen. The device or individual piece being tested.

1.1.6 Transfer time. The elapsed time measured from removal of the load from one bath until insertion in the other bath.

1.1.7 Worst case load temperature. The body temperature of a specific device located at the center of the load.

2. Apparatus. The baths used shall be capable of providing and controlling the specified temperatures in the working zone(s) when the bath is loaded with a maximum load. The thermal capacity and liquid circulation must enable the working zone and loads to meet the specified conditions and timing (see 3.1). Worst case load temperature shall be continually monitored during test by indicators or recorders reading the monitoring sensor(s). The worst case load temperature under maximum load conditions and configuration shall be verified as needed to validate bath performance. *Perfluorocarbons that meet the physical property* requirements of table II shall be used for conditions B and C.

3. Procedure. Specimens shall be placed in the bath in a position so that the flow of liquid across and around them is substantially unobstructed. The load shall then be subjected to condition A or as otherwise specified (see 4b) of table I for a duration of 15 cycles. Completion of the total number of cycles specified for the test may be interrupted for the purpose of loading or unloading of device lots or as the result of power or equipment failure. However, if the number of interruptions for any given test exceeds 10 percent of the total number of cycles specified, the test must be restarted from the beginning.

3.1 Timing. The total transfer time from hot to cold or from cold to hot shall not exceed 10 seconds. The load may be transferred when the worst case load temperature is within the limits specified in table II. However, the dwell time shall not be less than 2 minutes and the load shall reach the specified temperature within 5 minutes.

TABLE I. Physical property requirements of perfluorocarbon fluids. 1/

Test condition		B	C	ASTM test method
Step 1	Boiling point, °C	>125	>150	D1120
	Density at 25°C gm/ml	>1.6		D941
	Dielectric strength volts/mil	>300		D877
	Residue, microgram/gram	<50		D2109
	Appearance	Clear, colorless liquid		Not applicable
Step 2	Density at 25°C gm/ml	>1.6		D941
	Dielectric strength volts/mil	>300		D877
	Residue, microgram/gram	<50		D2109
	Appearance	Clear, colorless liquid		Not applicable

1/ The perfluorocarbon used shall have a viscosity less than or equal to the thermal shock equipment manufacturer's recommended viscosity at the minimum temperature.

TABLE II. Thermal shock temperature tolerances and suggested fluids. 1/

Test conditions		A and B	C	D
		Temperature	Temperature	Temperature
Step 1	Temperature tolerance, °C	100 +10 -2	125 +10 -0	150 +10 -0
	Recommended fluid	Water 2/ or perfluoro-carbon 3/	Perfluoro-carbon 3/	Perfluoro-carbon 3/
Step 2	Temperature tolerance, °C	-0 +2 -10	-55 +0 -10	-65 +0 -10
	Recommended fluid	Water 2/ or perfluoro-carbon 3/	Perfluoro-carbon 3/	Perfluoro-carbon 3/

1/ Ethylene glycol shall not be used as a thermal shock test fluid.
2/ Water is indicated as an acceptable fluid for this temperature range. Its suitability chemically shall be established prior to use. When water is used as the fluid for condition A and the specified temperature tolerances are insufficient due to altitude considerations, the following alternate test conditions may be used:
   a. Temperature: 100°C -6°C, 0°C +6°C.
   b. Cycles shall be increased to 20.
3/ Perfluorocarbons contain no chlorine or hydrogen.

4. Test condition A, radioisotope wet gross leak test.

4.1 Apparatus. The apparatus required for the seal test shall be as follows:

a. Radioactive tracer gas activation console.

b. Counting equipment consisting of a scintillation crystal, photomultiplier tube, preamplifier, ratemeter, and krypton-85 reference standards. The counting station shall be of sufficient sensitivity to determine through the device wall the radiation level of any krypton-85 tracer gas present within the device. The counting station shall have a minimum sensitivity corresponding to a leak rate of 10^{-9} atm cc/s of krypton-85 and shall be calibrated at least once every working shift using krypton-85 reference standards and following the equipment manufacturer's instruction.

c. A container of sufficient volume to allow the devices to be covered with oil and to be degreased with a suitable solvent.

d. Solutions:

(1) Hydrocarbon vacuum pump oil. The solution shall be kept clean and free of contaminants.

(2) Solvent capable of degreasing the devices.

e. A tracer gas consisting of a mixture of krypton-85 and dry nitrogen. The concentration of krypton-85 in dry nitrogen shall be no less than 100 microcuries per atmospheric cubic centimeter. This value shall be determined at least once each 30 days, following manufacturer's procedure, and recorded in accordance with the calibration requirements of this standard.

4.2 Procedure. The devices shall be immersed in the oil and evacuated to a pressure of 10 torr or less, for 10 minutes, and then pressurized for 1 hour at 45 psia minimum. The devices shall be removed from the oil and flushed with solvent to remove all of the surface oil. The devices shall then be placed in the radioisotope pressurization tank, and the tank evacuated to a pressure of 67 Pa (0.5 mm). The devices shall then be pressurized to a minimum of 3 atmospheres absolute pressure of krypton-85/nitrogen gas mixture for 2 to 5 minutes. The gas mixture shall then be evacuated to storage until a pressure of 267 to 333 Pa (2 to 2.5 mm Hg) maximum exists in the tank. This evacuation shall be completed in 2 minutes maximum. The tank shall then be filled with air, and the devices immediately removed from the tank and leak tested within 15 minutes after gas exposure, with a scintillation crystal equipped counting station. Any device indicating 1,000 c/m or greater above the ambient background of the counting station shall be considered a gross leak.

4.2.1 Personnel precautions. Government regulations require a license for the possession and use of krypton-85 leak test equipment. These regulations should be followed carefully. The personnel should be properly instructed and monitored in accordance with the licensing requirements.

5. Test condition B, radioisotope dry gross leak. This test shall be only to test devices that internally contain some krypton-85 absorbing medium, such as electrical insulation, organic, or molecular sieve material. This test shall be permitted only if the following requirements are met:

a. A 5 to 10 mil diameter hole shall be made in a representative unit of the devices to be tested.

b. The device shall be subjected to this test condition with a count rate from 200 to 250 counts per minute above ambient background. The count rate shall be made 2 hours after removal from the activation tank. If the device fails, this test condition may be used, but only for those devices represented by the test unit. If the device does not fail, this test condition shall not be used.

5.1 Apparatus. Apparatus for this test shall consist of the following:

a. Radioactive tracer gas activation console containing krypton-85/dry nitrogen gas mixture.

b. Counting station with a minimum sensitivity of 12,000 counts per minute per microcurie of krypton-85 tracer gas and a minimum detectable count rate of 100 counts per minute above background level.

c. Tracer gas mixture of krypton-85/dry nitrogen with a minimum allowable specific activity of 100 microcuries per atmosphere cubic centimeter. The specific activity of the krypton-85/dry nitrogen mixture shall be determined on a once-a-month basis as a minimum.

* 5.2 Procedure. The devices shall be placed in a radioactive tracer gas activation tank and the tank shall be evacuated to a pressure not to exceed 67 Pa (0.5 mm Hg). The devices shall then be subjected to a minimum of 173 Kpag (25 psig) of krypton-85/dry nitrogen gas mixture for 2 to 5 minutes. The gas mixture shall then be evacuated to storage until a pressure of 670 Pa (5.0 mm Hg) maximum exists in the activation tank. This evacuation shall be complete in 3 minutes maximum. The activation tank shall then be backfilled with air (air wash). The devices shall then be removed from the activation tank and leak tested within 30 minutes after gas exposure with a scintillation-crystal-equipped counting station. Any device indicating 200 counts per minute or greater above the ambient background of the counting station shall be considered a gross leak failure.

5.2.1 Personnel precautions. See 4.2.1.

6. Test condition C, liquid (fluorocarbon) gross leak.

6.1 Apparatus. Apparatus for this test shall consist of the following:

a. A vacuum/pressure chamber for the evacuation and subsequent pressure bombing of devices up to 618 kPag (90 psia) for a maximum of 24 hours.

b. A suitable observation container with provisions to maintain the indicator fluid at a temperature of 125°C ±5°C (100°C for Germanium transistors with temperature rating of 100°C maximum) and a filtration system capable of removing particles greater than 1 micrometer in size from the fluid.

c. A magnifier capable of magnifying an object 1.5 to 30 times its normal size (4 to 120 diopters) for observation of bubbles emanating from devices when immersed in the indicator fluid.

d. Sources of type I detector fluids and type II indicator fluids as specified in table II.

10.2.1 Evaluation of surface sorption. All device encapsulations consisting of glass, metal, and ceramic or combinations thereof including coatings and external sealants, shall be evaluated for surface sorption of helium before establishing the leak test parameters. Representative specimens of the questionable devices should be opened and all parts of each device as a unit shall be subjected to the predetermined pressure and time conditions established for the device configuration as specified in table V and 10.2.1.2. The measured leak rate for each device shall be monitored and the lapsed time shall be determined for the indicated leak rate to fall to ≤0.5 R_1 as specified in table V for test condition H_1 or as predetermined for test condition H_2. The average of the lapsed time following the release of pressure will determine the minimum usable dwell time. Note that the sensitivity of measurement increases as this background indicated-leak-rate decreases relative to the R_1 reject level. Alternately, whole (unopened) specimens of the questionable devices shall be subjected to the same process; then, the shorted value of lapsed time so obtained will determine the minimum dwell time. The fixed method will not be used if the consequent dwell time exceeds the value specified in table V. It is noted that sorption may vary with pressure and time of exposure so that some trial may be required before satisfactory exposure values are obtained.

10.2.1.1 Test condition H_1, fixed method. The device(s) shall be tested using the appropriate conditions specified in table V for the internal cavity volumes of the package under test. The t_1 is the time under pressure and time t_2 is the maximum time allowed after the release of pressure before the device shall be read. The fixed method shall not be used if the maximum standard leak rate limit given in the detail specification is less than the limits specified herein for the flexible method.

TABLE V. Fixed conditions for test condition H_1.

Volume of package (cm^3)	Bomb condition: kPaa ±15 (psia) ±2	Bomb condition: Exposure time in hours (t_1) (+1.0 - 0.0)	Bomb condition: Maximum dwell time (hour)	R_1 reject limit (atm cm^3/s)
< 0.05	517 (75)	2	1	5×10^{-8}
> 0.05 < 0.5	517 (75)	4	1	5×10^{-8}
* > 0.5 < 1.0	310 (45)	2	1	1×10^{-7}
> 1.0 < 10.0	310 (45)	5	1	5×10^{-6}
> 10.0 < 20.0	310 (45)	10	1	5×10^{-6}

10.2.1.2 Test condition H_2, flexible method. Values for bomb pressure, exposure time, and dwell time shall be chosen such that actual measured tracer gas leak rate (R_1) readings obtained for the devices under test (if defective) will be greater than the minimum detectable leak rate capability of a mass spectrometer. The devices shall be subjected to a minimum of 203 kPa (2 atmospheres absolute) of helium atmosphere. The chosen values of pressurization and time of pressurization, in conjunction with the value of the internal volume of the device package to be tested and the maximum equivalent standard leak rate (L) limit as specified in 10.2.2, shall be used to calculate the measured leak rate (R_1) limit using the following formula:

$$R_1 \frac{2.69\ L\ P_e}{P_o}\left[1-\exp-\left(\frac{2.69\ L}{P_o\ V}\cdot t_1\right)\right]\exp-\left(\frac{2.69\ L}{P_o\ V}\cdot t_2\right) \qquad (3)$$

Where: R_1 = The measured leak rate of tracer gas (He) through the leak in atm cm^3/s.

L = The equivalent standard leak rate in atm cm^3/s.

P_e = The pressure of exposure in atmospheres absolute.

P_o = 1 standard atmosphere.

t_1 = The time of exposure to P_e in seconds.

t_2 = The dwell time between release of pressure and leak detection in seconds.

V = The internal volume of the device package cavity in cubic centimeters.

The minimum detectable leak rate shall be determined as in 10.2.1 and shall be taken as the indicated value corresponding to a lapsed time $t_0 < t_2$. The lapsed time t_0 shall be taken as the minimum usable dwell time, and leak testing shall be accomplished in the interval between t_0 and t_2. Alternately, pressurization parameters may be chosen from the fine leak approximate solution of equation 3 for $L < 1 \times 10^{-5}$ as

$$L = \frac{P_o}{2.69}\left(\frac{R_1 V}{P_e t_1}\right)^{1/2} \qquad (4)$$

with a graphical representation given on figure 1071-1. If chosen dwell time t_2 is greater than 60 minutes, equation 2 shall be used to determine an R_1 value which will assure a maximum detectable standard leak rate large enough to overlap with the selected gross leak test condition. Alternately, the largest detectable leak rate L as a function of dwell time may be obtained from the approximate solution

$$L\,\max = \frac{P_o V}{2.69\ t_2}\ ln\left(\frac{2.69\ L\ P_e}{P_o R_1}\right) \qquad (5)$$

with graphical representation given on figure 1071-2. In each case (equations 4 and 5) R_1 shall be taken large compared to the minimum detectable value.*

10.2.2 Failure criteria. Unless otherwise specified, devices with an internal cavity volume of 0.01 cm^3 or less shall not be accepted if the equivalent standard leak rate (L) exceeds 5×10^{-8} atm cm^3/s. Devices with an internal cavity volume greater than 0.01 cm^3 and equal to or less than 0.5 cm^3 shall not be accepted if the equivalent standard leak rate (L) exceeds 1×10^{-7} atm cm^3/s. Devices with an internal cavity volume greater than 0.5 cm^3 shall not be accepted if the equivalent standard leak rate (L) exceeds 1×10^{-6} atm cm^3/s.

*From "Standard Recommended Practices for Determining Hermeticity of Electron Devices with a Helium Mass Spectrometer Leak Detector," ASTM Designation F134, Annual book of ASTM Standards, Pt. 43 November 1980.

3. Lead wires that do not deviate from a straight line from bond to external lead and appear to touch another wire or bond (Y plane only).

4. Any lead wire that touches or is less than 0.002 inch (0.0504 mm) from the case or external lead to which it is not attached (X and Y plane).

5. Any bond that is less than 0.001 inch (0.0254 mm) (excluding bonds connected by a common conductor) from another bond (Y plane only).

6. Any wire making a straight line run (with no arc) from die bonding pad to package post.

b. Round or "box" transistor type (see figure 2076-5).

1. Any lead wire that touches or is less than 0.002 inch (0.0504 mm) from the case or external lead to which it is not attached (X and Y plane).

2. Lead wires that stay below an imaginary plane across the top of the bond (X plane only).

3. Any lead wire that appears to touch or cross another lead wire or bond (Y plane only) if bonded to different electrical elements.

4. Any lead wire that deviates from a straight line from bond to external lead appears to touch or to be within 0.002 inch (0.0504 mm) of another wire or bond (Y plane only).

5. Any bond that is less than 0.001 inch (0.0254 mm) (excluding bonds connected by a common conductor) from another bond (Y plane only).

6. Any wire making a straight line run (with no arc) from die bonding pad to package post, unless specifically designed in this manner (e.g., clips, rigid connecting leads, or heavy power leads.

7. Any internal post that is bent more than 10 degrees from the vertical (or intended design position) or is not uniform in length and construction or comes closer than one post diameter to another post.

8. Any post in a low profile case (such as a TO-46) which comes closer to the top of the case than 20 percent of the total inside dimension between the header and the top of the case. Any device in which the semiconductor element is vertical to the header, and comes closer than 0.002 inch (0.0508 mm) to the header or to any part of the case.

c. Axial lead type (see figure 2076-7).

1. Whisker embedded with glass body wall.

2. Whisker tilted more than 5 degrees in any direction from the device lead axis or deformed to the extent that it touches itself.

3. Either half of an S or C bend whisker that is compressed so that any dimension if reduced to less than 50% of its design value. On diodes with whiskers metallurgically bonded to the post and to the die, the whisker may be deformed to the extent that it touches itself, if the minimum whisker clearance zone specified in figure 2076-7a, is maintained for metal packages.

4. Whiskerless construction device with plug displacement distance more than one-fourth of the diameter of the plug with respect to the central axis of the device.

5. Semiconductor element mounting tilted more than 15 degrees from normal to the main axis of the device.

6. Die hanging over edge of header or pedestal more than 20 percent of the die contact area by design.

7. Less than 75 percent of the semiconductor element base area is bonded to the mounting surface.

8. Voids in the welds which reduce the lead to plug connection by more than 25 percent of the total weld area.

9. Devices with package deformities such as, body glass cracks, incomplete seals (voids, position of glass, etc.), die chip outs, and severe misalinement of S- and C-shaped whisker connections to die or post that exceed the limits of the applicable visual inspection requirements.

3.9.3 Encapsulated non-cavity assemblies of discrete devices. External to the individual devices, the encapsulating material shall be examined and rejected for the following defects.

3.9.3.1 Extraneous material. Extraneous matter of any shape with any dimension exceeding 0.020 inches. Also, any two adjacent particles of such matter with total dimensions exceeding 0.030 inches.

4. Summary. The following conditions shall be specified in the applicable detail specification.

a. Number of views, if other than indicated in 3.1.1 and 3.1.1.1.

b. Radiograph submission, if applicable (see 3.8.2).

c. Marking, if other than indicated in 3.3 and marking of samples to indicate they have been radiographed, if required (see 3.3.3).

d. Sample defects and criteria for acceptance or rejection, if other than indicated in 3.9.

e. Radiograph and report retention, if applicable (see 3.8.3).

f. Test reports when required.

5.5 (K.CU) limit. (Slightly more involved but provides greater detail.)
This is a combinational approach that takes into account both K factor and power dissipation variations between devices.

5.6 $Z_{\Theta JX}$ limit. (For full characterization; not needed for screening purposes.)
The thermal impedance approach uses an absolute magnitude value specification that overcomes the problems associated with the other approaches. Thermal impedance is calculated as follows:

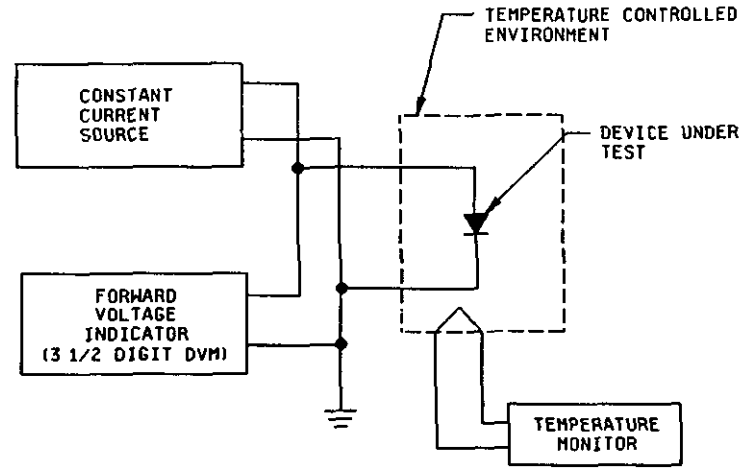
$$Z_{\Theta JX} = \frac{\Delta T_J}{P_D} \approx \frac{|(K)(\Delta V_F)|}{|(I_H)(V_H)|}$$

5.7 Θ_{JX} limit. (For thermal resistance specification testing.)
The thermal resistance to some defined point, such as the case, is an absolute magnitude value specification used for equilibrium conditions. The t_h heating time must therefore be extended to appreciably longer times (typically 20 to 50 seconds). In the example of $R_{\Theta JC}$ measurements, the case must be carefully stabilized and monitored in temperature which requires an infinite heat sink for optimum results. The ΘT_J is the difference in junction temperature to the case temperature for the example of $R_{\Theta JC}$.

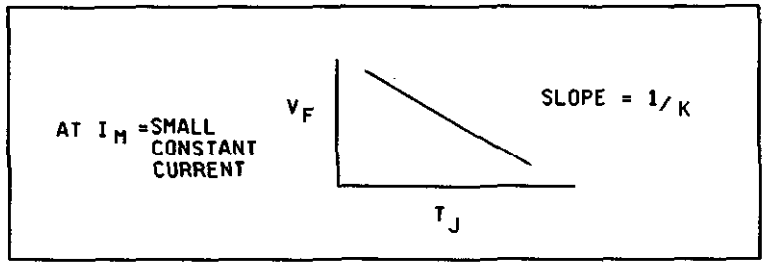
$$\Theta_{JX} = \frac{\Delta T_J}{P_D} = \frac{|(K)(\Delta V_F)|}{|(I_H)(V_H)|} \ ^\circ C/W$$

5.8 General comment for thermal transient testing. One potential problem in using the thermal transient testing approach lies in trying to make accurate enough measurements with sufficient resolution to distinguish between acceptable and nonacceptable diodes. As the diode-under-test current handling capability increases, the thermal impedance under transient conditions will become a very small value. This raises the potential for rejecting good devices and accepting bad ones. Higher I_H values must be used in this case.

6. Measurement of the temperature sensitive parameter V_F. The calibration of V_F versus T_J is accomplished by monitoring V_{SD} for the required value of I_M as the environmental temperature (and thus the DUT temperature), and is varied by external heating. It is not required if the acceptance limit is ΔV_F (see 5.2), but is relevant to the other acceptance criteria (see 5.3 through 5.6). The magnitude of I_M shall be chosen so that V_F is a linearly decreasing function over the normal T_J range of the device. I_M must be large enough to ensure that the diode junction is turned on but not large enough to cause significant self-heating. An example of the measurement method and resulting calibration curve is shown on figure 3101-3.



Step 1: Measure V_{F1} at T_{J1} using I_M
Step 2: Measure V_{F2} at T_{J2} using I_M
Step 3: $K = \frac{T_{J2} - T_{J1}}{V_{F2} - V_{F1}}$



I_M must be large enough to overcome surface leakage effects but small enough not to cause significant self-heating.

T_J is externally applied - via oven, liquid, etc. - environment.

FIGURE 3101-3. Example curve of V_F versus T_J.

A calibration factor K (which is the reciprocal of the slope of the curve on figure 3101-3) can be defined as:

$$K = \left| \frac{T_{J2} - T_{J1}}{V_{F2} - V_{F1}} \right| \ ^\circ C/mV$$

It has been found experimentally that the K-factor variation for all devices within a given device type class is small. The usual procedure is to perform a K factor calibration on a 10 to 12 piece sample from a device lot and determine the average K and standard deviation (σ). If σ is less than or equal to 3 percent of the average value of K, then the average value of K can be used for all devices within the lot. If σ is greater than 3 percent of the average value of K, then all the devices in the lot shall be calibrated and the individual values of K shall be used in determining device acceptance.

METHOD 3490

CLAMPED INDUCTIVE SWITCHING SAFE OPERATING AREA FOR MOS GATED POWER TRANSISTORS

1. Purpose. To define a method for verifying the inductive switching safe operating area for MOS gated power transistors, to assure devices are free from latch up.

2. Scope. This method includes all power MOSFETs and IGBTs used in switching applications for power supplies and motor controls.

3. Circuitry. As shown on figure 1, a simple inductive load circuit is employed. Drive circuitry applies a voltage to the device under test (DUT) to achieve a specified current. The turn-off dv/dt is controlled by a gate resistor. A clamping diode or suppression device is used to limit the maximum voltage which occurs during turn-off. The clamping device must be located as close as possible to the device under test to minimize voltage spikes due to stray inductance L_s.

4. Definitions:

T_J	-	Junction temperature (C°): Shall not exceed maximum rating of the device under test.
T_A	-	Ambient temperature (C°): Temperature used to heat the device under test.
T_C	-	Case temperature (C°): Temperature of the device under test as measured on the exterior of the package as close as possible to the die location.
V_{CC}	-	Collector supply voltage, dc.
V_{CF}	-	Clamping voltage.
V_{CES}	-	Collector to emitter voltage gate shorted to emitter.
V_{DSS}	-	Source to drain voltage gate shorted to source.
V_{DM}	-	Maximum off state voltage measure at the device under test which is caused by stray inductance between the device under test and the voltage suppressor. V_{DM} is due to L di/dt generated during turn-off.
I_L	-	Load current through inductor and device under test.
V_G	-	Drive voltage from a voltage source used to turn-on and turn-off the MOS device under test to achieve a specified current.
R_g	-	Resistor in series with the gate which is used to limit turn-off dv/dt during switching.
dv/dt	-	Change in voltage during turn-on and turn-off measured between 75% and 25% of total clamp voltage during turn-off.
t_p	-	Pulse width between turn-on and turn-off of device under test.
L_s	-	Stray series inductance due to layout of circuit.
L	-	Series inductance.

5. Specification conditions. The following conditions shall be specified in the detail specification:

V_{CC}	-	V.
V_{CF}	-	V.
I_L	-	A.
$T_C = T_A$	-	°C.
L	-	mH.
t_p	-	μs.
dv/dt	-	V/μs minimum.
N	-	Number of pulses.

6. Acceptance criteria.

a. No degradation of blocking voltage at the end of test shall be permitted.

b. Latch-up or reduction of I_L shall not be observed.

c. DUT must meet group A, subgroup 2 limits.

7. Comments and recommendations.

a. Gate resistor or gate drive source must be as close as possible to device under test to minimize oscillations during turn-off.

b. Gate resistor valve or gate drive is selected to assure minimum peak dv/dt is achieved.

c. V_{CF} clamping device should be as close as possible to device under test to minimize voltage over shoot. A general guideline is V_{CF} should not exceed 110% of V_{DM} and must be less than avalanche breakdown of device under test.

d. L should be selected to assure peak current is reached. The I_C will not be reached if too large of an inductor is used.

e. Safety precautions should be taken when testing high voltage devices and rules and regulations for handling high voltage devices should be followed.

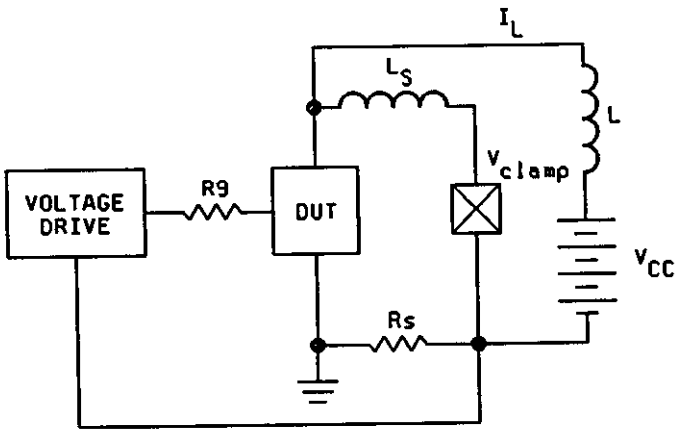
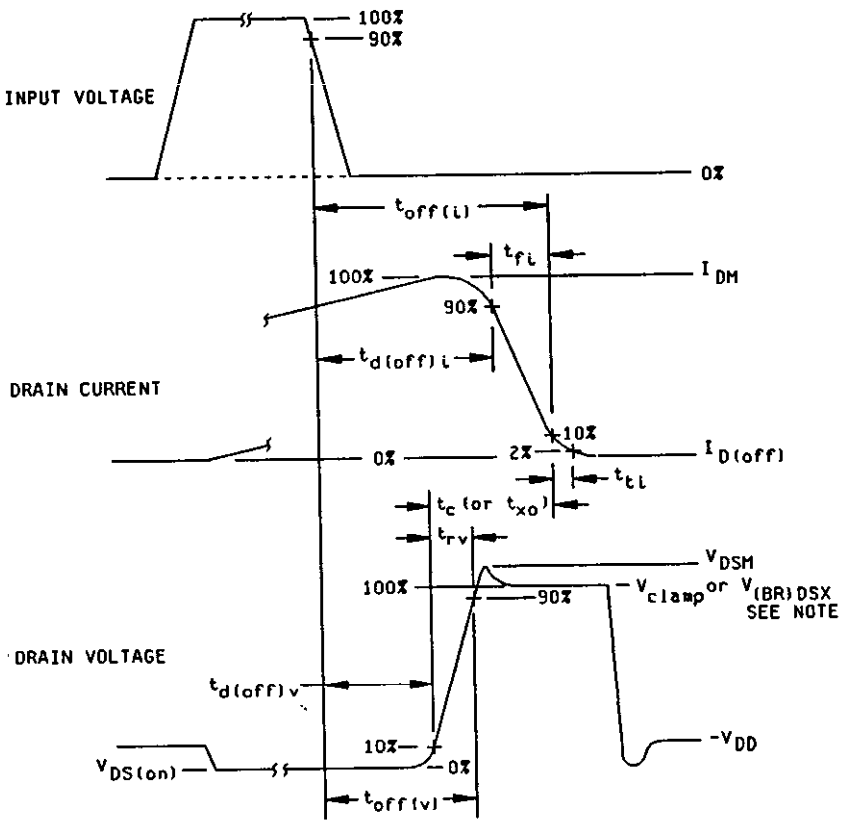


FIGURE 1. Inductive load circuit.



NOTES:
1. V_{clamp} (in a clamped inductive-load switching circuit) or $V_{(BR)DSX}$ (in an unclamped circuit) is the peak off-state.
2. Drain and source references for Mosfets are equivalent to collector and emitter references for IGBTs.

FIGURE 2. Inductive load waveform.

METHOD 5002

CAPACITANCE-VOLTAGE MEASUREMENTS TO DETERMINE OXIDE QUALITY

1. Purpose. The purpose of this test is to determine the quality of an oxide layer as indicated by capacitance-voltage measurements of a metal-oxide semiconductor capacitor. The overall shape and position of the initial C/V curve can be interpreted in terms of the charge density, and to a certain extent charge type, at the oxide-semiconductor interface. By applying an appropriate bias while heating the sample to a moderate temperature (e.g., 200°C), the mobile ion contamination level of the sample oxide may be determined.

2. Apparatus/materials. Capacitance-voltage plotting system complete with heated/cooled stage and probe (Princeton Applied Research Model 410, MSI Electronics Model 868 or equivalent). A C/V plotter may be constructed from the following components (see figure 1 for equipment setup).

2.1 Manual setup.

a. L-C meter (Boonton 72B or equivalent).

b. X-Y recorder (hp 7035B or equivalent).

c. DC voltmeter (Systron Donner 7050 or equivalent).

D. DC power supply, 0-100 volts.

e. Heated/cooled stage (Thermochuck TP-36 or equivalent).

f. Probe in micromanipulator.

2.2 Automatic C/V plotter. (CSM-16 or equivalent).

3. Suggested procedure.

3.1 Sample preparation.

a. The sample is typically a silicon wafer on which has been grown the oxide to be measured, or wafers with known clean oxide which is exposed to a furnace at temperature to measure the furnace cleanliness. An array of metal dots on the surface of the oxide provides the top electrodes of the metal-oxide-semiconductor capacitors. The metal may either have been deposited through a shadow mask to form the dots, or it may have been deposited uniformly over the oxide surface and then etched into the dot pattern by photolithographic techniques. Cleanliness of the metal deposition is paramount. Contamination introduced during metal deposition is as catastrophic to the oxide quality as is contamination introduced during oxide growth. The metal shall have been annealed, except in cases where the method is being used to investigate the effectiveness of annealing.

NOTE: This test may also be used to determine metal deposition system cleanliness when used with oxide samples known to be contamination free.

b. The minimum dot size should be such that the capacitance of the MOS capacitor is > 20 Pf.

c. The oxide thickness is typically 1,100 angstroms. Reduced sensitivity results from oxide thickness greater than 2,000 angstroms.

d. The backside of the sample shall have the oxide removed to expose the silicon. The backside may have metal, such as aluminum or gold deposited on it.

3.2 C/V plot (at room temperature).

a. Place the wafer on the heated/cooled stage. Use vacuum to hold the wafer firmly in place.

b. Zero the capacitance meter as necessary, place the paper in X-Y plotter and set-up the voltage source for the desired ranged.

c. Select the capacitor dot to be measured and carefully lower the probe to contact it.

d. Lower the pen on the X-Y plotter and sweep the voltage over the desired range so a C/V trace for an N-type substrate or P-type substrate, similar to that shown on figure 2 is obtained.

NOTE: If an anomalous trace is obtained, it may be because the capacitor is leaking or shorted. In this case, another dot should be selected.

3.3 Mobile ion drift.

a. Use the capacitor dot measured in 3.2.4.

b. With the probe making good contact, apply a positive bias of 10°volt/cm to the capacitor dot. (For a 1,000 angstrom thick oxide, this is a 10-volt bias.) A different voltage is acceptable, if the manufacturer can demonstrate effectiveness.

c. Heat the sample to 300°C ±5°C, -5°C with the bias applied. Hold at this temperature for three (3) minutes (different times may be acceptable if the manufacturer can demonstrate effectiveness).

d. With the bias still applied, cool the sample to room temperature (the heating and cooling cycle can be automatically programmed if the Thermochuck system is used).

NOTE: Be certain that the probe does not lose contact with the capacitor dot during the heat/cool cycle. If it should, the test is invalid and should be repeated.

e. Lower the pen on the X-Y plotter and sweep the voltage over the range necessary to obtain a C/V trace similar to that obtained in 3.2.4. The trace may be displaced on the voltage scale from the original trace, but should be parallel to the original trace. Label this trace as the (+) trace.

f. Apply a negative bias of the same magnitude selected in 3.3.2 to the capacitor dot and repeat steps 3.3.3 and 3.3.4.

g. Lower the pen on the X-Y plotter and sweep the voltage over the range again. This trace may be displaced from the two previous traces and should be labeled as the (-) trace.

h. An automatic system that performs equivalent functions may be substituted for steps 3.3.2 and 3.3.7.

3.4 Interpretation.

a. Determine the ΔV_{FB} (voltage difference between original trace and bias trace, taken at 90 percent capacitance level - see figure 2).

b. Determine the mobile ion contamination concentration, N_o, as follows:

$$N_o = \frac{\epsilon 0 \, K_{ox} \, \Delta V_{FB}}{q \, t_{ox}}$$

Where: $\epsilon 0$ = Permittivity of free space (8.85×10^{-12} coulomb volt $^{-1}$ m^{-1}).

K_{ox} = Dielectric constant of the oxide (3.8 for silicon dioxide).

q = The charge on an electron (1.6×10^{-19} coulomb).

t_{ox} = Oxide thickness (in meters).

Example:

ΔV_{FB} (measured from C/V curves similar to the ones on figure 2) = 1.4 volts.

t_{ox} (measured on wafer prior to metal deposition) = 950 angstrom.

$$N_o = \frac{(8.85 \times 10^{-12}) \, (3.8) \, (3.14)}{(1.6 \times 10^{-19}) \, (950 \times 10^{-10})} = 3.1 \times 10^{15}/\text{meter}^2 = 3.1 \times 10^{11}/\text{cm}^2$$

So, the mobile ion contamination-level is 3.1×10^{11} mobile ions per square centimeter in this example.

c. Considerably more information concerning the oxide and the semiconductor substrate can be obtained from interpretation of the C/V trace.

4. Summary.

4.1 Calibration. The voltage scale calibration of the X-Y plotter should be checked against the DVM during set-up. Other instruments should be calibrated at regular intervals.

4.2 Accuracy. The voltage accuracy obtainable is ±0.1 volt and the ΔV_{FB} accuracy obtainable is ±0.2 volt. The practical lower limit of detectability of mobile ion contamination is on the order of $2 \times 10^{11}/\text{cm}^2$.

4.3 Documentation. Record results in appropriate control document.

Reference:

Whelon, N.V., "Graphical Relation Between Surface Parameters of Silicon, to be Used in Connections with MOS Capacitance Measurements", Phillips Res. Apt., 620-630 (1965).

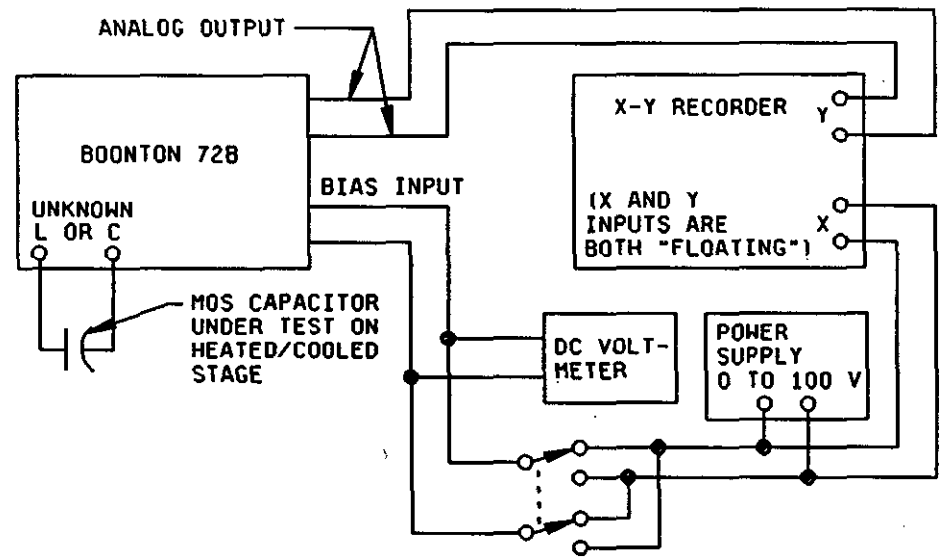


FIGURE 1. Diagram of equipment set-up for measuring relationship of metal-insulator-semiconductor structures.

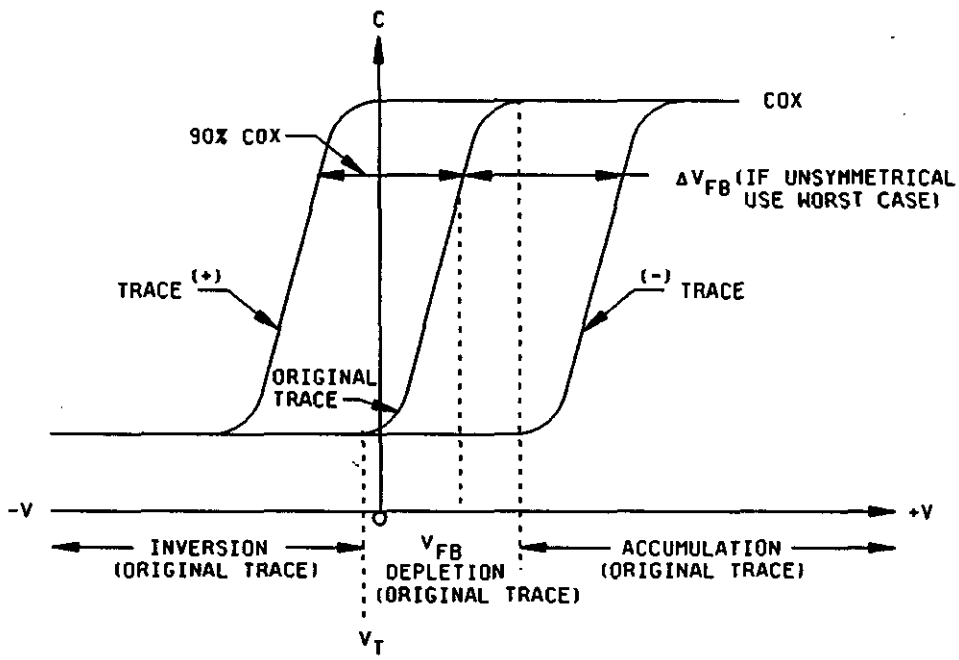


FIGURE 2. C/V traces.

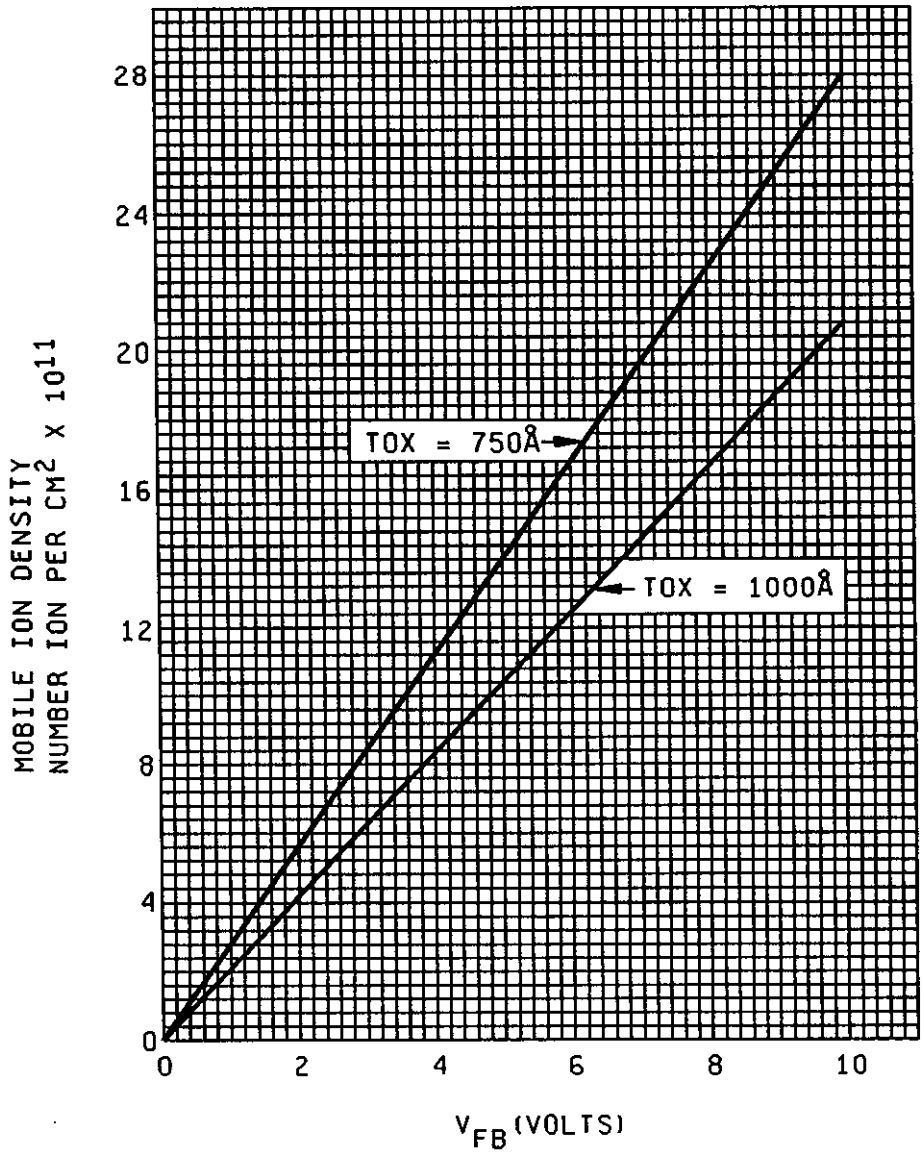


FIGURE 3. Mobile ion density vs. voltage shift (V_{FB}).